DOCUMENT RESUME

ED 235 013 SE 043 267

AUTHOR Osborne, Roger; And Others
TITLE Focus on Knowledge. Learning in Science Project. Working Paper No. 3.
INSTITUTION Waikato Univ., Hamilton (New Zealand).
PUB DATE Jul 79
NOTE 24p.; For related documents, see ED 226 976 and SE 043 265-315. Document contains some marginal legibility.
AVAILABLE FROM University of Waikato, Science Education Research Unit, Hamilton, New Zealand.
PUB TYPE Reports - Evaluative/Feasibility (142) -- Reports - Research/Technical (143)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Academic Achievement; Concept Formation; *Concept Teaching; *Curriculum Development; Elementary School Science; Elementary Secondary Education; Force; Interviews; Language; Learning; Physical Sciences; Science Curriculum; Science Education; *Science Instruction; *Scientific Concepts; *Secondary School Science; Student Experience
IDENTIFIERS *Learning in Science Project; *New Zealand; Science Education Research

ABSTRACT

The first (exploratory) phase of the Learning in Science Project focused on science teaching/learning in the Form 1 to 4 level (ages 10 to 14) and sought to identify problems and difficulties in several areas. Provided in this paper are comments obtained during structured/unstructured interviews (from students, ex-students, teachers, headmasters, science advisers, and inspectors) and observations made by project staff related to science knowledge/concepts. The intent in presenting these comments/observations is not primarily to provide a balanced view of good and bad aspects for Form 1 to 4 science, but rather to open up problem issues as project staff and others see them. Comments/observations focus on: (1) why basic ideas/concepts are not being acquired; (2) concepts and language (considering words having both popular and technical meanings, and the teaching of force); and (3) scientific knowledge and children's experience (considering statements based on established theory and those based on children's experience, and the lack of correspondence due to limitations in children's experiences). Questions raised from discussions of the comments/observations are included. Also included (in an appendix) are extracts from individual interviews in which students were asked their meaning of the word "force." (JN)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

LEARNING IN SCIENCE PROJECT

ED235013

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

✓ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

FOCUS ON KNOWLEDGE

"PERMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY
Roger Osborne
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

University of Waikato
Hamilton, N.Z.

SE043267

WORKING PAPER No 3

The Learning in Science Project is an educational research project undertaken at the University of Waikato under contract to the NZ Department of Education. The project is initially investigating the problems and difficulties of Form 1 - 4 Science (10 - 14 year olds) as a first step to improving teaching and learning.

This paper is one of a set of essays which is an outcome of the exploratory phase of the project. It is our hope that feedback from these essays will assist further to clarify issues and assist us in establishing priorities for the in-depth phase of the project. Any comments our readers have on either the issues involved, or the methodology adopted in these papers, would be most welcome.

Learning in Science,
University of Waikato,
Private Bag,
Hamilton,
NEW ZEALAND.

FOCUS ON KNOWLEDGE

A WORKING PAPER OF THE LEARNING IN SCIENCE PROJECT

Roger Osborne, Peter Freyberg and Ross Tasker

July 1979

This is one of a set of discussion papers which focus on various aspects of Form 1-4 Science. The paper collates comments and observations, related to the topic of focus, which were obtained during the first phase of the Learning in Science Project. In this phase we were particularly concerned about problems and difficulties in Form 1-4 Science and because of this the paper is biassed toward issues as identified by pupils, ex-pupils, teachers, headmasters, science advisers, inspectors as well as by our own observers. Our intention in writing the discussion papers is therefore not primarily to provide a balanced view of the good and bad aspects of Form 1-4 Science but rather to open up problem issues as we and others see them, to a limited but wider audience than the project team.

It is our hope that our chosen readers will be prepared to talk to us about the topic under focus in this paper in terms of the following questions:

(i) Are the issues we have raised important and central issues which are of general concern?

(ii) Are there other more basic issues, or other subsidiary questions, about the topic which we have overlooked?

(iii) Which aspects of the topic could we profitably analyze further in the in-depth phase of the project?

(iv) What possible solutions to some of the issues raised could profitably be the subject of further study?

INTRODUCTION

One of the underlying principles behind F1-4 Science teaching is that

> "factual knowledge and the broader perspective given by the fuller understanding of such facts (and ideas) are the basis of further study in science, the development of vocational and recreational interests and the formation of sound work habits and positive attitudes to source. While encouraging a wide range of other objectives teachers cannot escape both the responsibility and the need for pupils to learn something of the major achievements and basic concepts of science"
>
> (Draft Syllabus p.13)

However what is meant by 'factual knowledge', 'fuller understanding of facts', and 'basic concepts'? When one investigates this it appears that at least some teachers associate knowledge with rote learning.

> "Oh, I could teach knowledge no trouble ... I could put it all up on the board ... and then I could say to them 'right learn up those and I will test you in 3 weeks' time'. How long they'd be remembered is another thing but I could then say they had the knowledge"
>
> [experienced intermediate teacher]

9/3/3

However this type of knowledge is not under scrutiny in this paper. What is under focus is the meaningful understanding of scientific statements (e.g. facts, principles or theories). Such meaningful understanding requires a good understanding of what might be called basic concepts. To understand 'If the net force on a body is not zero it will accelerate,' requires a good understanding of the scientist's concepts of force and acceleration.

Many people do see the understanding of such basic concepts as the above as central to the learning of science,

> "I still think we should try and teach basic concepts ... the concept of force, the concepts of atoms and molecules ... these (type of concepts) are basic concepts for understanding"
>
> [secondary science inspector]

58/3/3

> "I think the science concepts that they are supposed to know are important"
>
> [experienced intermediate teacher]

9/18/1

However there is the problem of deciding what precisely constitute the basic concepts and what level of concept understanding children of a particular level should be expected to acquire.

While the intention to teach basic facts and concepts is present, it would appear that some of the basic scientific ideas are not being understood adequately by children.

17/4/3 "I don't think they are understanding concepts and some of those concepts that these kids have grabbed hold of - I don't know who's been teaching them (but) its incredible some of the stuff that comes across."

[HOD, Science]

20/1/3 "There is something wrong somewhere because we have to repeat each and everything each year. When they move from F3 to F4, whatever they have learnt in F3 is not there wher they move into the 4 Form, then we repeat again in F5."

[secondary teacher]

This view is supported to some extent by our own work, in a limited field, and by a number of comments which suggest reasons why basic ideas and concepts are not being acquired. These include

(i) we don't teach basic concepts and ideas effectively or we don't teach them at all.

58/4/1 "I would say about half the teachers I have seen can teach the (basic) concepts quite successfully ... there are more teachers who have the scientific concept themselves who could use it fairly mechanically but would not be able to teach it"

[secondary science inspector]

23/12/2 "Children find it hard to understand physical concepts ... perhaps it hasn't been clear in the minds of the teachers who taught them"

[secondary teacher]

38/10/2 "When we come on to things like energy I am not very sure"

[intermediate teacher]

63/3/2 "I think the big problem comes ... the moment a teacher gets a question that he can't answer. If he is a man then he starts talking technically at the kids and often the technical stuff is quite incorrect ... it is just what he remembers from his own schooldays."

[primary inspector]

(ii) abstract concepts, particularly in the physical sciences are difficult to teach

25/20/3 "There are areas in physics and chemistry which are pretty difficult blooming abstractions. Trying to convince a group of 13 year old kids that developing an idea of what happens inside this test tube because chemical reactions are an important set of changes that they should be aware of is pretty difficult. But if you are dealing with a consumer and you have got a rabbit in front of you then it is real and it smells. The test tube is real and it smells and what is going on inside is real and it smells too, but when you ask people to take the smell and think about it in terms of atoms being rearranged and molecules whizzing around then you have got a big problem."

[HOD, Science]

21/1/3 "I think that (physical science concepts) are difficult for kids to understand, it is difficult for the teacher to explain also because you cannot get down to the right conceptual level to explain them in a way that kids can understand ... certainly some of it anyway"

[HOD, Junior Science]

(iii) basic ideas are difficult for children to learn, sometimes impossible.

16/1/3 "I didn't really understand this business about kinetic energy and all that ... I know we didn't do much depth and perhaps I just skimmed over it."

[ex-pupil]

16/8/2 "Physics was mainly abstract ideas and it was hard"

[ex-pupil]

21/3/3 "Light is energy ... a form of energy or can transmit energy is pretty difficult for them ... even at the 4 form level ideas about energy are quite difficult to understand ... as they are for anyone including teachers."

[HOD, Junior Science]

20/22/1 "Just the concept of atoms was difficult because they couldn't see it ... they couldn't conceive one ... it was just a thing that they had to accept ... that this little crystal is made up of millions and millions of atoms ... sure they could see the crystal, they could see it dissolve, they could see it regrow, but what was happening to the atoms - oh gosh (laughs)"

[secondary science teacher]

58/6/3
58/9/3 "I think often (the basic concepts being taught) are conceptually beyond the kids. I don't think the lower 30% (of the full ability range) will ever, never mind now, reach the intellectual maturity to cope

[science inspector]

(iv) <u>to understand basic ideas and concepts you have to think them through and many children do not think</u>.

35/4/3 "I think that there is a natural tendency of kids to want to sit back and be supplied with stuff ... a lot of kids, particularly slower kids are quite happy to sit back and copy things off the blackboard ... but they are not so happy to be put in a position of having to do something for themselves ... I don't think this is the kids' fault ... I think it is our fault ... in that somewhere along the line I feel we have got to introduce some materials so the kids are working things out for themselves and thinking ... provided that it is kept to a level appropriate to them ... to their mental age.

[science inspector]

20/23/2 "Perhaps that they are not quite at the conceptual level of understanding. They can't think in the abstract perhaps ... some of them."

[secondary teacher]

20/26/3 "A lot of people were not thinking about it ... they just treated science as a bit of a game."

[3F pupil]

75/8/2 "The teachers didn't encourage any thinking or anything like that ... I suppose you were supposed to think about it but not 'understand it' I suppose is the word."

[ex-pupil]

13/3/2 "It was all very dry and mathematical and I just switched off - consequently I got lost because I wasn't particularly interested."

[ex-pupil]

42/4/2 Some of the above quotes (i) - (iv) suggest that teachers
41/3/1 are not always confident about teaching basic ideas. Often this lack of confidence is justified because of their lack of background, in science at the F1 and 2 level and in the science teachers' non-
18/6/2 specialist subjects at the F3 and 4 level. If the teachers' own concepts are shaky this inevitably leads to inadequate teaching. There is also an argument that teachers are not guided on how to teach basic concepts or on how to appreciate the learner's point
39/8/3 of view.
23/12/3

> 42/4/2 "I can understand (the ideas) but putting in (the children's) place is very difficult"
>
> [intermediate teacher]

16/8/1 Many would argue that too many concepts are 'thrown too
16/1/3 quickly' at children and that some concepts are just impossible
58/6/3 to teach to some children as they are just too abstract.

Is the problem one of just trying to teach inappropriate concepts or are there other difficulties and problems in teaching and learning which are resulting in poor understanding of basic ideas and concepts? In the next section some of the teaching and learning problems associated with language and concepts are discussed, by analyzing in some depth the teaching and learning of one particular basic concept. In a subsequent section the nature of scientific knowledge is analyzed and related to classroom teaching.

CONCEPTS AND LANGUAGE

One of the problems in teaching and learning is that many words used in science have both a popular and a technical meaning. If teachers do not make it clear that these two different ways of using a particular word exist and the pupil, in turn, does not appreciate this point, considerable problems in pupil learning can arise.

> 63/3/3 "These subtleties (between the technical and popular use of words) are the things where we are missing out."
>
> [primary inspector]

To explore this, one specific example will be considered. Force is a central and basic concept in physical science and is indeed a central concept in both F1 and 2, and F3 and 4 syllabuses It is necessary to appreciate the technical use of the word force, simply to push or pull, as an appreciation of this is required to understand many basic ideas in science including weight, gravity, acceleration, work, power, energy and so on. Unfortunately the word also has a popular usage and if students confuse this with the technical use of the word, fundamental problems will arise.

Teachers do have difficulty teaching the concept of force and they often consider children have difficulty learning about force.

26/5/1 "I feel I need time and resource materials and help from a physics minded person to help with the topic FORCE. I need some help (with) how to apply the ideas in the classroom ... especially at the F3 level ... it is trying to get it across in a simple enough way that they would understand it and enjoy it."

[secondary teacher]

21/7/1 "I sometimes wonder how much is being attained in understanding of what forces are ... it is difficult to know whether kids are understanding them or not."

[HOD, Junior Science]

23/13/1 "When you come to newtons and joules and work and power and energy they get them all confused ... If you sat down and thought through this sequence of work very carefully I am sure that you would be able to present it to them so that they could get a good grip of each section ... but many teachers just throw it at them in a week or two weeks and the kids get rather muddled because the presentation was a bit muddled."

[3rd year secondary teacher]

39/9/3 "The topic forces is sort of covered (by us) but if you asked a physicist to look at what concepts were developed I am not sure that he would say that they are very good at all."

[experienced intermediate teacher]

The teaching of force like other physical science topics also suffers from teacher attitude,

25/7/3

> "I find some topics more to my liking than others. And so I do, unless I make a conscious effort to avoid it, I tend to spend more time talking about those topics than others, and dealing with those topics than others ... things like mechanics and electricity ... those topics haven't ever interested me greatly enough for me to want to find out a lot of things about them myself ... . And that is bad in a way, because it does mean that unless I make a big effort not to I could give the kids rather a bias."
>
> [secondary science teacher]

Using an Interview about Instances method (see Appendix) 38 students were interviewed about their concept of force. The main findings of this investigation were:

(a) All of the children had some sort of concept of force but this concept varied greatly. Some 9 year olds have a relatively good scientific concept of force while even some second year Teachers College students had a typical 9 year old concept. This later concept is the popular concept of 'to force' or 'forcing' and the concept if often closely associated with movement or human endeavour, or both.

(b) The younger children tended to have the idea that a moving body contains force by virtue of its motion (i.e. the physicist's concept of momentum is assumed to be a force). This concept appears to be relatively persistent and continues to be held by some students even after 6 or 7 form training in physics.

As a secondary school inspector stated to us,

58/4/2

> "A youngster always has the popular concept and so do a lot of adults ... we have got to give the separate specialized physics concept of force ... this specialized usage is not being taught I don't think ... this I think is part of the problem ... (there is a problem in the teacher?) in his concepts and his ability to separate the technical meaning and what I call the popular meaning both in his and the kids' minds ... unless he is prepared to do this ... (the kids can't differentiate?) they can't and the teacher can't and they are not going to get very far."

And what does he suggest?

> "I think the only answer is a very definite spelling out of "yes there are all these usages of the word force but we want to keep the word here (in this topic) to mean this and only this ... it is probably the only safe way ... to say we are referring to physical pushes and pulls and things like them ... if I am pushing you or pulling you that is a force ... it may move you it may not but it is still a force and if I am not pushing you I don't care what you are doing there is no force."

Observations in classrooms support the view that even where the concept force is taught there is ample opportunity for a child's popular concept of force to be reinforced by the teacher, often unintentionally, but sometimes deliberately because the teacher's own concept is not clear (or does not include the usual scientific distinctions).

Let us give one specific example of how it is so easy for the popular concept to be reinforced. The situation is a group discussion with teacher and class about a rolling ball-bearing.

Teacher: "Why doesn't the ball-bearing go right through the person's hand when he puts it there to stop.

Student: "It has not got enough force to go through it."

Teacher: "Good boy - it has not got enough force to go through it."

A physicist too might well agree in general terms with the student's answer, but he, like the teacher, would probably not interpret the answer in the way the student meant it.[1] In that sense the student's concept that the ball has a force by virtue of its motion, is reinforced. Not only is this student's defective concept (from the scientific view) reinforced but so is the concept of other children who think of it in this way. Later at least one other child wrote in her book - "the ball does not have enough force

---

[1] *This student had been interviewed prior to the lesson to establish his meaning of the word force.*

to go through our hand. We have more force than the ball."

The above is given in some detail without any criticism of the teacher but simply to show just how subtle and difficult the problem is.

Finally the problem may also be inherent in curriculum materials used by the teacher. The curriculum developers' attempts to simplify the situation for children sometimes results in materials which reinforce the popular concept rather than the scientific one. For example it is interesting to consider the following extract from curriculum materials being used in an observed classroom in the light of the children's comments on the bike card detailed in the Appendix (the word CAR has been replaced by BIKE).

> "You know that a force is needed to start something moving. The object then continues to travel on its own. However unless a force acts to keep the (bike) moving it will slow down and eventually stop."
>
> "Friction is a force which acts in the opposite direction to the force which is causing the movement."

Again this statement can be interpreted meaningfully by physicists but in the light of comments by children detailed in the Appendix, many children will not interpret it in the way intended. Rather they will interpret it in a way which will reinforce their scientific misconceptions. Again the subtelties of the situation can be appreciated without criticism of the curriculum intent.

In summary, force is a central topic to meaningful understanding of physical science. Teachers find it difficult to teach and they consider children have difficulty. Children do have various concepts of force but often the concepts are not the scientific ones and this makes it difficult to appreciate and understand the technological world in which they live, e.g. ideas of energy requirements, friction, gravity, space travel and so on. Finally it is very easy for teachers and teachers' curriculum materials to quite unintentionally enhance the scientific misconceptions of children.

While we have dealt in some detail with one particular concept it is not an isolated case. We have seen many cases of confusion in children's minds caused by insufficient explanation on the part of the teacher as to the differences between the popular and technical usage of a word. Examples we have observed include the words work, community, population, habitat, charge, aim, and electricity. Often teachers will ask questions with the technical usage of a word in mind the the children will answer with the popular use of the word in mind.

T: (pushing on a desk) Am I doing work? (technical use in mind)

P's: (chorus) Yes. (popular use in mind)

T: No I am not.

P: Yes you are.

If at this point the teacher sees the problem and explains the different but legitimate uses of the word all is well. However how many teachers have been trained to be sensitive to the problem?

SCIENTIFIC KNOWLEDGE AND CHILDREN'S EXPERIENCE

In the last section the point was made that there are two kinds of language in science teaching and learning and we, as teachers, do not always distinguish clearly between them although it is important to make the distinction. In this section a similar dichotomy will be explored between two kinds of scientific knowledge and again the argument will be put forward that in our teaching we often do not distinguish between them. The learning of scientific knowledge at the school level largely relates to the learning and understanding of scientific statements. Some scientific statements are of the type "All objects accelerate downwards at $9.8ms^{-2}$," "acid plus some metals produce a salt," "animal communities consist of pyramids of predators" while others are of the type "the block and the ball fell at different rates," "the acid had no effect on the metal," "a spider and 5 small bugs were found on the flax bush." The first type are statements based on established theory while the second type are statements based on children's experience. Fig 1 is an attempt to display this distinction diagrammatically. Statements based on theory are implications from theories that have been developed

over centuries by the best scientific brains. Statements based on experience come from children's limited experience of either everyday life or contrived laboratory situations. While the differences in the types of statements may be clear in the above examples the distinction between the two is not always made in teaching and learning and this can cause problems.

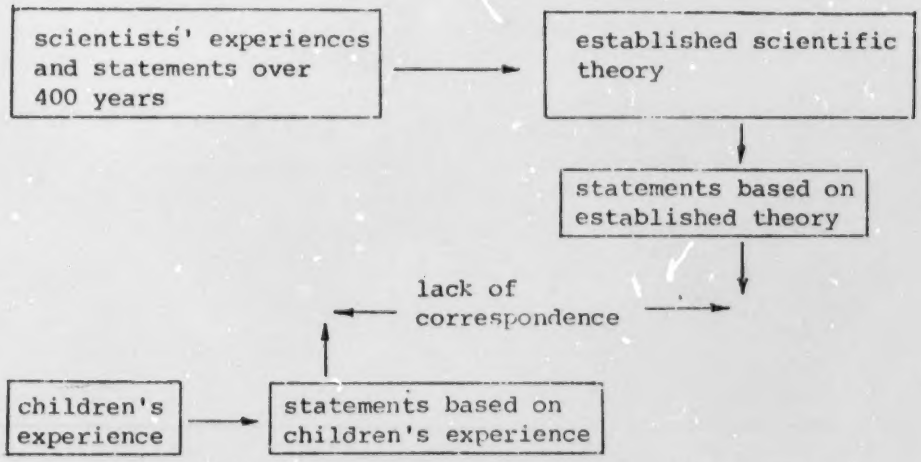

scientists' experiences and statements over 400 years
established scientific theory
statements based on established theory
lack of correspondence
children's experience
statements based on children's experience

Fig 1: Relationship between statements based on theory and statements based on children's experience, and the lack of correspondence due to the limitations in children's experiences.

The main problem of attempting to teach established scientific knowledge meaningfully to children is the problem of reducing the 'lack of correspondence' in Fig 1. With limited time, limited apparatus, and limited finance for field trips it is difficult, if not impossible, to give children sufficient experiences, contrived or otherwise, so that the children's statements that can be based on experience will be similar to the statements based on established theory. Teachers who feel that expository teaching is not desirable are left with a credibility gap if they wish to teach aspects of established scientific theory.

58/6/2

> "the experiments didn't give them the experience and the students hadn't the intellectual ability to even begin to see what we were taking for granted in asking the questions."
>
> [science inspector]

73/3/3

"there are many children at this level that just don't have the skills necessary to apply themselves with any degree of diligence to arrive at the conclusion that you want. We have the teaching staff available ... we have the children working in groups at times ... we have them working individually at times ... it doesn't seem to affect it ... it is just a thing that seems to be occurring all the damn time."

[intermediate teacher]

This point is also reflected in the following teachers' comments.

20/23/2

"Very often they can see the physical results but drawing the conclusions from these results - which requires a lot of thought - that is often quite difficult. Perhaps it's because ... it's the level of understanding that they are at ... perhaps they are not quite at the conceptual level of understanding ... they can't think in the abstract perhaps ... some of them."

[secondary science teacher]

25/13/2

"To some people the result is obvious. Say we mix iron and sulphur "I mixed two things and they glowed in the test tube and there is something different there now." (statement based on experience.) A lot of kids are quite happy to have mixed it together and seen that it has got hot and had a good play and they don't really care about the result ... and I find that's quite hard to develop a line of thought. I am very keen to make sure it (a statement based on theory?) is illustrated with the experiment, but to actually get kids to develop a thought that a chemical reaction means something comes out different at the end ... to develop that sort of idea with some kids seems almost wasting time."

[experienced secondary teacher]

Whether the experiences children have had are based on everday experiences, laboratory demonstrations or individualised experimental work the problem still remains. Subsequent classroom discussion can be fraught with difficulty as the lack of correspondence between pupil statements based on experience and teacher statements based on theory begins to occur. Often, as we have observed in classrooms, teachers and pupils are at cross purposes. Consider the following:

66/1-11 An intermediate teacher had heated camphor which was smelt by those at the front bench and later by pupils at the back of the room. In the subsequent classroom discussion the teacher asked questions with statements based on theory in mind, but pupils kept answering with statements based on experience in mind.

T: How did the gas get to the back of the room? (with statements based on theory in mind - molecules).

P: It expanded (statement of experience in mind in terms of what he means by expand).

LATER as the teacher continued to search fruitlessly for an answer which contained statements based on theory.

T: I want you to think what the molecules look like travelling through the air. (a statement of theory in mind - molecules move in an irregular path).

P: We couldn't see them (a statement based on experience!).

Eventually, at the end of the lesson, conclusions were just written down on the board for children to copy down. The first conclusion was "all matter is made of small particles".

This is not an isolated instance. It seems from our experience that teachers with limited background knowledge consisting of a few 'statements based on theory' will often attempt to evoke these statements out of children who only have 'statements based on their experience' with which to reply. Many children just get lost in the hail of questions as teachers attempt, often in vain, to elicit the statements based on theory from children who do not have the experience to provide them (and who are possibly interested in something else that interested them about the problem, e.g. how does 'smell' work?).

More experienced teachers may well 'solve' this by a sleight of intellectual argument,

58/1/3 "There was often a slight glib discussion of a mere facet (statement based on experience?) then the teacher, the kids or both produced a tremendous generalization (statements based on theory?) and that worries me."

[science inspector]

Where statements are produced by teachers, often pupils appear to accept them despite the fact that their own evidence or experience do not support the statements. We watched children attempting to charge up balloons in one classroom and attempting to get them to repel without success. However in subsequent discussion the teacher said they repelled and everyone accepted it. What sort of science is this? Would it not be better for children to record, or say, clearly and honestly what they did observe, e.g. "with our balloons although they stuck to the walls and our arms they did not repel each other," and be complimented by the teacher for a good scientific account of their work? Would it not be better for pupils to say "when we heated the camphor, Joe in the front row smelt it first, then Ken in the next row smelt it and finally Mary in the back row smelt it."?

What then of statements based on theory? Perhaps we first need to think very carefully whether for children of a particular age we wish to introduce statements based on theory at all, particularly where there is a considerable lack of correspondence between statements based on experience and statements based on theory.

> "I found the gorse bush topic a bit booky ... you look at a typical gorse bush and come back and copy out all the relationships that you can find in the gorse bush community (statements based on theory) rather than the kids getting out and having a go - even if they are wrong - of trying to draw up relationship diagrams (diagrams based on experience).
>
> [experienced intermediate teacher]

WHERE DO WE GO FROM HERE?

Many questions are raised in the above. Should we attempt to teach basic concepts and scientific theories at the Form 1-4 level, and if so what level of understanding should children of a particular age be expected to have acquired? How much of the difficulty that children have in acquiring ideas in science is a problem of the intellectual level of the children and how much is associated with the kind of teaching they receive?

How important is it for teachers to clarify and distinguish in their own minds, and then help pupils to clarify and distinguish, the differences between the popular and technical usage of particular scientific words?

Should teachers be encouraged to distinguish more clearly between pupil statements based on experience and teacher statements based on theory? How frequently at any particular level do we want to go beyond the pupil statements based on experience? Should we be leading children to statements based on theory or should we be allowing children to follow up the questions generated in their minds by the initial experimental work.

Do you agree that there tends to be a 'lack of correspondence' between 'statements based on experience' and 'statements based on established theory' in many science lessons? If so, is this an important issue and how might we reduce this lack of correspondence?

ACKNOWLEDGEMENTS

We are grateful to all those people who so freely talked to us about F1-4 Science. We also wish to thank the teachers and pupils who so willingly allowed us to join them in their classroom activities.

With regard to the preparation of this particular paper we are grateful to our colleagues, Bev Stead and Mark Cosgrove for valuable discussions.

APPENDIX

THE INTERVIEWS ON FORCE: Individual student interviews asking pupils their meaning of the word 'force'.

Std 1	201		
3	203-207	Pre Form 1-4 teaching	7
4	202		
Form 1	208-216	Pre Form 1-2 teaching	9
3	217-226	Pre Form 3-4 teaching	10
5	227* 228* 229* 230* 231*	Post F 1-4 teaching	12
2nd Year T.C.	232, 233* 234* 235*** 236** 237* 238		
		TOTAL	38

* SC Science ** UE Physics *** 7 Form Physics

Note:

1: The school children came from 7 different schools.
The 2nd year T.C. students came from 7 different schools.

2: In the following pages:

(a) Each asterisk represents a similar set of replies.

(b) The first set of replies on each page indicates some appreciation by students of the physicist's concept of force in terms of the way the instance is discussed.

(c) The quoted reply is that of the student whose number immediately follows the quote. All subsequent numbers gave replies which were in essence basically those given, although the actual words used may have been different.

A POLICEMAN MOVING A DEMONSTRATOR

IS THERE A FORCE ON THE DEMONSTRATOR ?

- "YES... BECAUSE THE POLICEMAN IS TRYING TO PULL HIM" 203
  "YES... BECAUSE HE IS BEING PULLED" 210,229,230,232,236
  "YES... BECAUSE HE IS EXERTING A FORCE TO MOVE HIM" 227,235
- "YES BECAUSE HE IS BEING FORCED TO DO SOMETHING" 209,214,215,225
  "YES BECAUSE HE IS FORCING HIM TO MOVE" 213,223,226,233,238
- "ONLY IF HE WAS FIGHTING (OR STRUGGLING)" 204,212
  "IF HE WAS DOING SOMETHING WRONG" 206,212
  "NO... HE IS JUST RELAXING" 207
  "YES... BECAUSE HE IS GOING WITHOUT HIS WILL" 219,221,222,224
- "NO... THERE IS A FORCE ON THE POLICEMAN BUT NOT ON THE DEMONSTRATOR ... BECAUSE OF POLICE FOR ..." 218
  "NO... THE POLICEMAN HAS A FORCE ON HIM BECAUSE HE IS MOVING BACKWARDS BUT THE DEMONSTRATOR IS NOT DOING ANY WORK" 231

THE MAN IS TRYING TO MOVE THE CAR BUT THE CAR IS NOT MOVING

IS THERE A FORCE ON THE CAR ?

"YES... BECAUSE THE MAN IS PUSHING THE CAR" 207,210,223,227,229,230,236,237
"YES... THE MAN'S FORCE IS PUSHING IT BUT IT IS NOT MOVING" 218,228,232
"YES... TRYING TO PUSH IT ... TRYING TO MOVE IT" 220

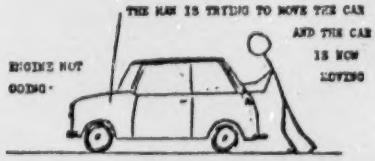
"YES... HE IS FORCING THE CAR" 205,216,221,224,225,226
"YES... HE IS TRYING TO FORCE IT TO GO" 209,213,234

"NO... IT IS NOT MOVING" 201
"NO... BECAUSE HE CANNOT GET IT TO MOVE" 211,214
"NO... I DONT THINK SO BECAUSE HE IS NOT FORCING THE CAR, THE CAR WON'T MOVE ... IT WOULD BE TOO HEAVY (IF HE WAS MOVING THE CAR) YES HE WOULD PROBABLY HAVE A GOOD FORCE ON THE BACK WINDOW (BUT IF IT WAS NOT MOVING?) OH HE WOULD BE ARGUING AT THE CAR ... KICKING IT ... THEN HE WOULD PROBABLY START WALKING ... HE WOULD DO A FORCE IF IT WAS A BRAND NEW CAR (HOW DO YOU RECKON THAT?) WELL HE WOULD PROBABLY WAVE OUT TO ANOTHER CAR THAT PASSES BY ... TRY AND SAVE HIS CAR INSTEAD OF LEAVING IT OUT" 217

"NO BECAUSE IT CAN'T FEEL ANYTHING ... BUT THERE IS A FORCE ON THE MAN BECAUSE HE HAS TO PUSH IT AH THAT PUTS A FORCE ON HIM " 204
"I DON'T KNOW THE CAR HAS NOT GOT A BRAIN OR ANYTHING" 212

THE MAN IS TRYING TO MOVE THE CAR AND THE CAR IS NOW MOVING

ENGINE NOT GOING.



IS THERE A FORCE ON THE CAR ?

- "YES THE MAN IS PUSHING IT" 207,210,216,223,224,225,227,228,229,233
  "I SUPPOSE THERE IS ... HE IS PUSHING IT ALONG" 232
- "YES... THERE IS A FORCE BECAUSE HE IS FORCING IT TO GO" 205,230,234
  "... WELL HE IS FORCING THE CAR" 214
  "YES HE IS FORCING IT TO GO AGAINST ITS WILL" 221
- "NO HE IS NOT REALLY FORCING IT ... HE IS MORE JUST PUSHING IT" 213,222
  "NO... CAUSE IT IS MOVING AND IT IS REALLY A FORCE ON THE MAN CAUSE HE HAS GOT TO PUSH IT (IS THERE A FORCE ON THE MAN THEN?) YES (IS THERE A FORCE ON THE CAR?) NO" 215
- "YES... KINETIC ... IT IS MOVING FROM THE PERSON INTO THE CAR ... THE PREVIOUS ONE IS POTENTIAL ISN'T IT ... POTENTIAL ENERGY" 236
  "NO BECAUSE IT CAN'T FEEL ANYTHING" 204

IS THERE A FORCE ON THE CAR ?

"YES... THERE IS FRICTION AND WEIGHT AND THE FORCE THAT THE TYRES HAVE FROM THE MOTOR" 229

"YES THERE IS THE FORCE OF THE AIR ON IT (IS THAT THE ONLY FORCE?) THERE MIGHT BE A FORCE OF FRICTION (WHERE WOULD THAT BE?) ON THE WHEELS" 202, 228

"YES... THE AIR AS IT GOES FASTER THERE WOULD BE MORE PUSH, LIKE IF YOU PUT YOUR HEAD OUT OF THE WINDOW YOU WOULD FEEL IT" 219,236

"YES... THE ENGINE IS A FORCE PUSHING THE CAR FORWARD" 224,227

"YES... THERE WOULD BE A FORCE ON THE ENGINE" 203,212,223

"YES... THE ENGINE IS FORCING THE WHEELS TO MOVE" 209,210,220,233,238

"YES... BECAUSE WHEN YOU PUSH THE PEDAL THINGY (SIC) IT MAKES IT GO FASTER" 205,212

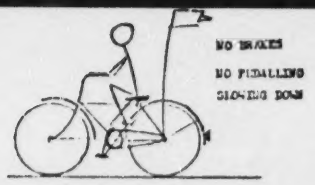
"YES... THE MAN IS PUTTING A FORCE ON THE CAR" 206,207,208,218

"YES... THE MAN IS FORCING IT TO GO FASTER" 213,214

"YES... THERE IS A FORCE ON THE PEDAL OF THE ACCELERATOR" 217,225,226,234

"NO (NO FORCE AT ALL?) NO (WHY NOT?) BECAUSE NO ONE HAS TO PUSH IT" 216,203, 211

"NO... I TAKE THE MEANING OF FORCE THAT IT IS MOVING BUT THAT THERE IS SOMETHING THERE STOPPING IT, BUT IN THAT CASE I DON'T EXPECT THERE IS ANYTHING STOPPING IT, SO ... THERE IS NO FORCE" 218



IS THERE A FORCE ON THE BIKE ?

- "YES (WHY?) BECAUSE SOMETHING IS TRYING TO SLOW IT DOWN ... BECAUSE SOMETHING IS PUSHING IT THE OTHER WAY AND IT SLOWS DOWN" 201,202,231

  "YES... JUST GOING ALONG WITH SOMEONE ON IT WOULD FORCE IT DOWN A BIT" 204,218

  "THERE MIGHT BE A FORCE TO SLOW IT DOWN FROM THE WIND OR THE WHEELS" 210,228,229

  "YES THE AIR AROUND IT IS FORCING IT" 224,225

  "YES... GRAVITY AND FRICTION" 227,230

- "YES... THE WHEELS ARE STILL GOING SO THAT THERE WOULD BE A FORCE FROM THAT" 203

  "IT IS JUST PUTTING FORCE ON BY ITSELF ... FROM THE FORCE YOU GAVE IT BEFORE" 209

  "YES... THE SPEED THAT HE HAS ALREADY GOT UP" 233

  "THERE IS A FORCE BECAUSE OF THE BIKE'S OWN MASS ... THE MASS OF THE BIKE HAS COME (TO) SUCH A SPEED THAT IT WON'T JUST STOP STRAIGHT AWAY ... THE FORCE IS STILL IN THERE ... IN THE BIKE ... THE FORCE WAS TRANSFERRED FROM THE PERSON PEDALLING ... AND IT IS NOW STILL ADHERENT IN THE BIKE ... THE BIKE STILL MOVES FORWARD" 235

- "NO... IF THE BIKE IS SLOWING DOWN ON ITS OWN ACCORD ... THERE IS NOT REALLY ANY FORCE REQUIRED AT ALL" 226

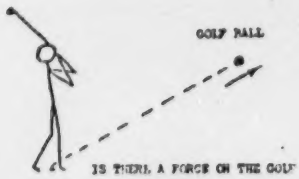
  "NO... NOT REALLY BECAUSE HE IS NOT PEDALLING OR ANYTHING" 206,211,213,215,21

  "NO NOT REALLY IT IS JUST SORT OF GLIDING (DRIFTING)" 220,223

  "NO IT IS KIND OF NATURAL" 221

  "NO NOT REALLY (THE FACT THAT IT IS SLOWING DOWN?) WELL IT HAS GOT NO ENERGY TO RUN IT ... THERE IS NO FORCE ON IT" 222

- "YES BECAUSE IT IS FORCING ITSELF TO STOP" 205



IS THERE A FORCE ON THE GOLF BALL ?

- "NO... BECAUSE THE MAN HAS ALREADY HIT IT AND IT IS JUST SAILING THROUGH THE AIR BECAUSE IT HAS ALREADY HAD ITS FORCE (ANY OTHER FORCE?) THE WIND" 210,212,223,224

  "THERE IS THE FORCE OF GRAVITY AND THERE IS ACCELERATION BUT THAT IS NOT A FORCE" 229

- "THERE HAS BEEN A FORCE ON THE BALL BUT I DON'T THINK IT IS STILL BEING FORCED ... I DON'T KNOW ... THE FORCE HAS BEEN APPLIED AND IT IS NOW MOVING ALONG BECAUSE OF THAT (THERE IS NO FORCE ON IT NOW?) IN THOSE TERMS BUT THERE IS PROBABLY SOMETHING ELSE THAT IS MOVING IT ALONG BUT I CANNOT EXPLAIN" 238

  "I AM NOT SURE ... PERHAPS THERE IS NOT BECAUSE THE MAN HAS HIT IT (EARLIER) BUT THERE COULD BE A FORCE TO KEEP IT GOING" 207,222

- "YES BECAUSE THE MAN WOULD BE HITTING IT AND THERE WOULD BE A FORCE ON THE BALL (WHICH) WOULD BE GETTING LESS AS IT GOES UP" 203,208,209,211,213,214, 226,230

  "YES THE WEIGHT AND THE FORCE FROM THE GOLF STICK (DOES THE FORCE FROM THE HIT JUST HAPPEN AT THE BEGINNING?) IT SLOWLY DIES OUT" 205,218,231,232,234

  "I SUPPOSE THERE IS BECAUSE THE FORCE FROM WHEN HE HIT IT IS STILL ON IT" 220,221,227

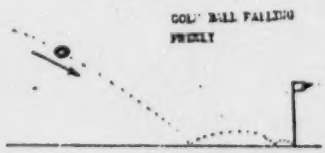
  "THE FORCE FROM THE HIT IS STILL ... IT WOULD STOP IF IT WASN'T THERE" 225,228

  "YES I THINK THERE WOULD STILL BE A FORCE ... BUILT UP FROM WHEN THE GUY HIT IT (ANY OTHER FORCE?) THE AIR GOING THE OTHER WAY FORCING IT TO SLOW DOWN" 233

  "[illegible] THE FORCE OF THE HIT ON IT, GRAVITY, AIR RESISTANCE ..." 236

  "THE WIND AS WELL AS THE KINETIC ENERGY FROM THE GOLF CLUB (IS THAT A FORCE?) YES" 236

- "NO, BECAUSE THE GOLF BALL CAN'T FEEL ANYTHING ... IT IS JUST MADE" 204



IS THERE A FORCE ON THE GOLF BALL ?

- "YES THE FORCE OF GRAVITY AND POSSIBLY AIR" 202,210,229,237

  "GRAVITATION (ANY OTHER FORCES ON IT?) NO" 227,238

- "YES ... THE WEIGHT OF THE BALL AND STILL SOME FORCE FROM THE HIT" 205,211 221,223,232,234

  "WELL IT HAS PROBABLY LOST ALL THE FORCE FROM THE HIT ... BECAUSE IF IT STILL HAD THE SAME FORCE THAT IT HAD AT THE STARTING POINT IT WOULD JUST KEEP ON GOING SO IT IS STARTING TO LOSE THAT FORCE THROUGH FRICTION BEATING IT BACK AND GRAVITATIONAL PULL BRINGING IT DOWN" 228,230

- "NO IT IS JUST DROPPING FREELY (NO FORCE?) I DON'T THINK SO" 201,206,213, 214,220,221,226

  "NO BECAUSE ONCE IT IS IN THE AIR IT JUST STARTS GOING DOWN AND IT IS JUST GOING DOWN BECAUSE OF ITS WEIGHT (WEIGHT ISN'T A FORCE?) NO" 212

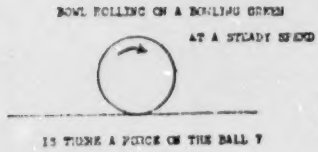
  "NO THERE ISN'T MUCH FORCE COMING DOWN BECAUSE ALL THE WEIGHT IS TAKEN OFF" 215

  "NO BECAUSE IF IT IS DROPPING... NOTHING IS HELPING IT ... IT JUST GOES PLONK BY ITSELF" 216

  "GRAVITY (IS THAT A FORCE?) OH I SUPPOSE IT IS BUT I DON'T SEE IT AS A FORCE" 221,222

- "IT IS LOSING (THE FORCE FROM THE HIT) SO IT IS COMING DOWN (ANY OTHER FORC NO ... THERE COULD BE THE FORCE OF THE WIND" 207,209,211,225,236

  "NO IT IS JUST SORT OF FALLING AFTER THE FORCE OF THE HIT IS FINISHED (WHEN DID IT FINISH) AT THE HIGHEST POINT" 224,231



"YES THE GRASS HITTING THE BALL AND SLOWING IT DOWN A BIT" 210,220,225

"THERE WOULD HAVE TO BE TO MAKE IT MOVE BUT I DON'T THINK THERE WOULD BE (NOW)" 221,226

"THE BALL CAN'T STOP ITSELF ... SO THERE IS A FORCE ON THE BALL" 208,215, 224

"THE FORCE FROM WHEN THE BOWLER LET IT GO WILL STILL BE INSIDE IT ... IT HAS NOT FINISHED" 236,238

"YES ITS OWN WEIGHT AND MOMENTUM GIVEN BY THE PERSON (IS MOMENTUM A FORCE?) YES" 233,236

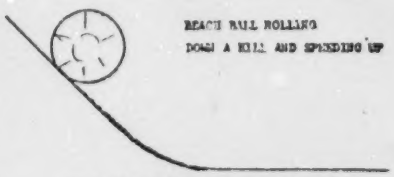
"YES BECAUSE THE MAN PUSHED IT (IS THAT FORCE STILL ON THE BALL?) YES (BUT IT IS GETTING LESS)" 205,211,214,220,222,232,234

"YES THERE IS A FORCE ON IT BECAUSE IT IS STILL MOVING AND THE FORCE (THE FORCE FROM THE PUSH (C.F. GOLF CLUB)?) YES MOST OF IT (WOULD THE FORCE FROM THE PUSH BE GETTING LESS AS IT GOES ALONG?) YES ... IT COULDN'T BE THE SAME ELSE IT WOULD JUST KEEP GOING" 207,209

"YES HE PUT PRESSURE ON IT AND THE PRESSURE IS STILL MAINTAINING AS IT GOES ALONG" 225

"YES... BECAUSE THE MAN HAS PUSHED IT AND PUT A FORCE ON THE BALL ... IF THERE WASN'T IT WOULD BE STANDING STILL ... (THE FORCE) WOULD BE GETTING LESS" 203,209

"NO BECAUSE IT DOESN'T REALLY MATTER WHAT SPEED YOU BOWL THE BALL UNLESS ... WELL YOU JUST WANT IT TO GO REALLY NICE AND SLOWLY SO IT CAN GO AROUND ... THERE IS NO REAL FORCE ON IT ... (WHAT ABOUT WHEN YOU PUSHED IT TO START WITH (C.F. GOLF BALL)?) NO THAT WAS MORE JUST PUSHING IT ... IT WAS NOT FORCING IT" 213



- "YES... GRAVITY IS PUSHING IT" 201,210,219

  "YES... THERE IS THE GRAVITATIONAL PULL WHICH COULD PULL IT DOWN ... WHICH WOULD MAKE IT GO FASTER DOWN THE HILL ... AND FRICTION IS THERE AGAIN" 208,228,236

  "YES THE FORCE OF THE AIR BRUSHING UP AND FRICTION WITH THE GROUND" 202,223

- "THERE IS A FORCE OF GRAVITY PUSHING DOWN AND THE EARTH PUSHING AGAINST IT ... BUT SOMEHOW IT IS MOVING DOWN HILL ... THERE MUST BE A FORCE SOMEWHERE" 232

  "GRAVITATIONAL PULL ... IT WOULD STILL HAVE THE PRESSURE OF THE AIR AND FRICTION BUT IT IS STILL SPEEDING UP ... I CAN'T UNDERSTAND WHY" 237

  "I CAN'T EXPLAIN THAT APART FROM GRAVITY I SUPPOSE HELPING IT TO GO DOWN ... I THINK OF IT AS A FORCE BECAUSE YOU SAY THE FORCE OF GRAVITY BUT IT IS A PULL RATHER THAN A PUSH AND I THINK OF A FORCE AS A PUSH RATHER THAN A PULL" 238

  "UM THERE IS GRAVITY ... THAT WOULDN'T BE A FORCE IS IT (WELL IS IT ACCORDING TO YOU?) NO ... BECAUSE A FORCE USUALLY MEANS A PUSH OR PULL ... OR NOT PULL MAINLY PUSH ... DO WHAT IT DOESN'T WANT TO ... NO THERE IS PROBABLY NO FORCE ON THAT" 220

- "NO IT JUST NATURALLY ROLLS DOWN" 222

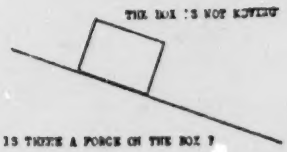
  "NOT REALLY JUST FALLING DOWN" 214,216,226

  "I DON'T THINK SO ... IT IS JUST GOING DOWN WITHOUT ANY FORCE WITH IT" 203,206,209,211,212

- "I DON'T KNOW IF IT IS FORCING ITSELF" 205

  "YES IT IS FORCED TO GO FASTER (BY) THE SLOPE OF THE HILL" 216,221,234

  "THERE COULD BE THE WIND ... BUT MOST OF IT WOULD BE THE HILL BECAUSE IT IS GOING DOWN" 207,210,224,226



(LIMITED SAMPLE)

- "YES... THE GRAVITY HOLDING IT DOWN" 224,230,232,233

  "YES... THE FORCE OF GRAVITY AND FRICTION" 227,228,229

- "YES... THE FORCE TO STAY THERE ... BECAUSE IF THERE WASN'T ANY FORCE IT WOULD JUST ROLL DOWN ..." 207

  "I SUPPOSE THERE IS A BIT OF FORCE BECAUSE IT HAS GO TO FORCE ITSELF TO STAY UP (WHAT IS THE FORCE?) JUST STAYING STEADY" 209

- "NO... BECAUSE IT IS NOT REALLY ... IF IT WAS FALLING OVER IT COULD HAVE RESISTED THE SLOPE SORT OF ... BUT BECAUSE IT IS STILL QUITE STABLE IT IS NOT REALLY FORCED" 221

  "NO... BECAUSE BOXES ARE SQUARE AND SOMETIMES THEY GET STUCK ('STUCK' NOT A FORCE?) NO" 205

- "YES BECAUSE ... THERE WOULD BE A FORCE MAINTAINING ITS SHAPE ... OTHERWISE IT WOULD COLLAPSE" 226

- "YES BECAUSE OF THE WEIGHT OF THE PERSON" 204,208,207,210,213,220,221 222,227,228,230,232

- "YES BECAUSE WHEN YOU ARE SITTING ON IT ... IT WOULD GO DOWN A BIT" 203,205,211,212,214 223,224,226,236,237

- "YES BECAUSE THE PERSON IS FORCING IT DOWN" 209,216,217,239

IS THERE A FORCE ON THE BAR ?

- "YES... THE STRENGTH OF THE MAN HOLDING IT UP AND GRAVITY (PULLING IT DOWN)" 210,218,227,228,230,232,236,237

  "YES FROM THE WEIGHTS PULLING IT DOWN" 221,226,223,228

- "YES HE IS FORCING THE BAR TO STAY UP" 217

  "YES BECAUSE THE MAN IS HOLDING IT UP IN THE AIR" 211,234

  "YES BECAUSE (THE BAR) IS TRYING TO FORCE ITS WAY DOWN BUT HE WONT LET IT" 209

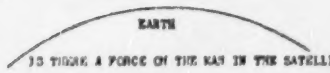
- "NO BUT THERE IS A FORCE ON THE PERSON" 204,212,233,238

  "NOT REALLY THE MAN IS FORCING THE BAR" 214

  "NO... THERE IS MORE A FORCE ON THE PERSON ... ALL THE BAR HAS TO DO IS TO SIT THERE IN THE AIR WITH THE MAN HOLDING IT" 206,213,216,219, 225

- "NO... HE IS NOT PUSHING IT EITHER WAY ... HE IS JUST HOLDING IT STEADY" 202,208,228

  "NO I DON'T THINK SO ... BECAUSE NOTHING IS LIFTING IT AND IT ISN'T MOVING" 205,232



IS THERE A FORCE ON THE BOY IN THE SATELLITE ?

(MANY PRIMARY SCHOOL CHILDREN SAID THAT THEY DID NOT KNOW ABOUT SATELLITES SO THIS QUESTION WAS NOT PERSUED WITH THOSE CHILDREN)

- "YES...A BIT OF GRAVITY...NOT ENOUGH TO PULL IT BACK DOWN BUT IT IS JUST ENOUGH TO SAVE IT FROM GOING AWAY" 219,225,228,230,235,237

- "NO BECAUSE THERE IS NO GRAVITY UP THERE" 201,223,224,227

  "NO BECAUSE THE SPACE WHERE THE SATELLITE WOULD BE WOULD BE AIRLESS SO THERE IS NO FRICTION ...NO WEIGHT...(IF YOU HAVE NO AIR YOU HAVE NO WEIGHT?) NO ITS VACUUM...NO FRICTION...NO WEIGHT" 229

  "THERE IS NO GRAVITY HE IS OUT OF THE ATMOSPHERE" 232

  "NO BECAUSE HE WOULD BE OUT OF THE ATMOSPHERE AND IT WOULD BE FREE (WHY DOESN'T THE SATELLITE FALL DOWN?) DON'T KNOW" 213,217

- "I DON'T KNOW" 211,222,229

  "YES KEEPING THE SATELLITE UP (WHAT KEEPS IT UP?) SIGH ..I DON'T KNOW" 210

  "YES HE IS FORCED TO STAY IN THE SATELLITE HE CAN'T JUST HOP STRAIGHT OUT" 218,233

  "YES... HE IS TRYING TO FORCE THE SATELLITE TO GO AROUND" 209

- "NO HE SORT OF FLOATS AROUND IN THE SATELLITE ... ONLY IF HE HIT THE WALL" 210,220

  "ON THE SATELLITE NOT ON HIM" 236

  "NOT REALLY ... HE IS NOT REALLY DOING ANYTHING ... IT IS GOING AUTOMATICALLY" 221

  "NO ... NOT REALLY ... IT IS JUST GOING AROUND FREELY AS THE EARTH TURNS (WHY DOESN'T IT FALL DOWN?) BECAUSE THE AIR IS MAKING IT RISE" 226

A DISCUSSION WITH A 10 YEAR OLD ABOUT THE SATELLITE

"EXHILED SPACE MAN (WHY) IN HIS PRISON OF WAR CAMP ... (CHUCKLE) ... NOT REALLY (A FORCE) UNLESS HE HAS GOT ARTIFICIAL GRAVITY (WHAT DOES THAT MEAN?) WELL IF HE IS IN SPACE THERE IS NO GRAVITY AND YOU CAN CREATE IT BY HAVING THE THING TURNING AROUND ... SO IF IT HAD THAT IT WOULD BE GRAVITY (IN SPACE THERE IS NO GRAVITY?) NO BUT IT CAN BE CREATED (YOU SAID BEFORE THE PLANE HAD GRAVITY ON IT) HM HM (HOW HIGH UP WOULD THE PLANE HAVE TO BE BEFORE THERE WASN'T ANY GRAVITY ON IT?) I DON'T REALLY KNOW (HAVE YOU ANY IDEA?) WELL IT DEPENDS WHAT YOU MEAN IN TERMS OF GRAVITY ... LOTS OF GRAVITY ... YOU SEE HOW FAR YOU HAVE TO GO TO GET OUT OF GRAVITY ... IT WOULD BE A LOT OF GRAVITY, SOME GRAVITY, NO GRAVITY ... IT WOULD SORT OF THIN OUT ... (WELL YOU SORT OF SAID A SATELLITE HAD NO GRAVITY) DEPENDING ON HOW FAR ... OH NO IT HAS GOT GRAVITY ... JUST A MINUTE ... BECAUSE IT IS ALWAYS FALLING TOWARDS THE EARTH ... NOT NECESSARILY DOWNWARDS BUT IT IS FALLING LIKE THAT ... I READ THAT SOMEWHERE ... IT IS FALLING ALL THE TIME BECAUSE IT IS JUST FALLING IN A CIRCULAR PATH LIKE THIS (DEMONSTRATES CIRCULAR PATH) NOT GETTING ANY CLOSER TO THE EARTH BUT ALWAYS FALLING ... SO I GATHER THERE MUST BE SOME GRAVITY ON IT BECAUSE IF THERE WAS NO GRAVITY IT WOULD SHOOT STRAIGHT OUT (IS THERE A FORCE ON THE MAN?) THERE IS NO FORCE ON HIM I DON'T THINK (JUST ON THE SATELLITE NOT ON HIM) JUST A MINUTE ... I DON'T THINK THERE WOULD BE SO MUCH FORCE ON HIM AS ON THE SPACE CRAFT (O.K. SO WHAT ARE YOU SAYING? THERE IS SOME GRAVITY UP THERE?) YES (WELL HOW FAR WOULD THAT GRAVITY GO? WOULD IT GO AS FAR AS THE MOON?) WELL IT COULDN'T GO AS FAR AS THE MOON ... THE MOON HAS ITS OWN GRAVITY ... I WOULDN'T HAVE ANY IDEA HOW FAR YOU WOULD HAVE TO GO (IS THE MOON GOING AROUND THE EARTH?) YES I THINK SO ... YES (IT IS NOT LIKE A SATELLITE?) YES IT IS REALLY ... IT WAS THE FIRST SATELLITE ... (WELL YOU SAID THIS SATELLITE WE HAVE GOT HERE IS GOING AROUND BECAUSE IT HAS GRAVITY ACTING ON IT I JUST WONDER IF THE MOON WOULD ALSO BE GOING AROUND THE EARTH BECAUSE OF GRAVITY ACTING ON IT) OH I SEE ... POSSIBLY BUT WHEN WE ARE KEPT IN BY THE SUN SO IT MIGHT BE KEPT IN ITS PATH BY THE SUN . . THE GRAVITY OF THE SUN ... I AM NOT QUITE SURE ABOUT THAT BECAUSE I DON'T THINK GRAVITY COULD GO THAT FAR OUT ... (WHAT ABOUT THE EARTH GOING AROUND THE SUN?) YES THERE IS A GRAVITY ON THAT ... I CAN'T REMEMBER WHO IT WAS PROVED BY ... BUT SOME ANCIENT PERSON ... BECAUSE IT KEPT THE PLANETS IN THEIR PATHS ... IF THERE WAS NO GRAVITY ON THE SUN ... FROM THE SUN ... THE

A DISCUSSION WITH A 2ND YEAR TEACHERS COLLEGE STUDENT WITH S.C. SCIENCE

"I AM NOT SURE ... SOMETHING FORCES IT TO GO AROUND ... I DON'T KNOW WHAT THAT FORCE IS ... THE FORCE OF THE EARTH ISN'T IT (IS THAT TO DO WITH GRAVITY?) I THINK SO ... I AM NOT SURE BECAUSE I THOUGHT IF IT WAS TO DO WITH GRAVITY IT WOULD FORCE IT TO COME DOWN ... BUT IT STAYS THE SAME HEIGHT DOESN'T IT ... AND IT JUST MOVES APOUND (IS THERE ANY AIR UP THERE) TO ME YES ... YOU CAN'T IMAGINE SOMETHING WITHOUT AIR." 234

MAN STANDING ON THE MOON

20

IS THERE A FORCE ON THE MAN ?

- "YES... BECAUSE OF THE MOON'S GRAVITY" 206,214,215,227,228,229,234,235,237

- "NO BECAUSE HE ISN'T MOVING" 209,216

  "NO BECAUSE THERE WOULD BE NO GRAVITY AND HE CAN MOVE AS FREELY AS HE WANTS" 213,223,228

  "I WOULD NOT THINK SO BECAUSE IN THE MOON MOVIES THAT I SEE THEY JUST JUMP UP IN THE AIR AND LAND 20 - 30 FEET AWAY FROM WHERE THEY ARE ... I WOULDN'T THINK SO (YOUR REASON?) THERE IS NO AIR UP THERE ... YOU CAN JUST JUMP AROUND AND ALL THIS" 232

- "YES THE AIR OR SOMETHING IS FORCING HIM TO LIFT UP" 205

  "YES BECAUSE PEOPLE SAY THAT IT IS SORT OF HARD TO STAND ON THE MOON SO HE HAS GOT TO TRY AND FORCE TO TRY AND STAY THERE" 205

  "YES STANDING ON THE GROUND BECAUSE IF HE JUMPED OR SOMETHING HE WOULD GET LIFTED UP AND WOULD FLOAT AROUND" 210

- "NO BECAUSE THERE IS NO GRAVITY ON THE MOON ... BUT THERE IS WEIGHT ... THEY USE HEAVY SHOES TO WEIGH HIM DOWN" 230,232,233

  "HIS WEIGHT IS PUSHING HIM DOWN ... (BUT) THERE IS NO GRAVITY ON THE MOON" 225

  "NO ... ARE THE THINGS THAT THEY WEAR ON THE MOON HEAVY? (POSSIBLY) THERE IS NO FORCE ON THE MAN BUT THE CLOTHES ARE HOLDING HIM DOWN ... THERE WOULD HAVE TO BE A FORCE SOMEWHERE TO HOLD HIM TO THE MOON ... BUT THERE ISN'T GRAVITY ... THERE ARE NO OTHER FORCES" 234

THE FORCE OF THE AIR ... A THEME

THE FORCE OF THE AIR HAS A GREATER PROMINENCE IN CHILDREN'S MINDS THAT WE MIGHT ANTICIPATE: EXAMPLES, WHICH ARE NOT UNIQUE, FOLLOW

IS THERE A FORCE ON THE GOLF BALL (AS IT GOES UP)?
"YES BECAUSE WHEN THE MAN HITS THE BALL THE WIND IS FORCING IT UP THROUGH THE AIR WHEN HE HIT IT (WHAT ABOUT NOW?) YES BECAUSE THE WIND IS PUSHING IT FURTHER AND FURTHER AND THEN IT WILL JUST DROP STRAIGHT DOWN (WHERE DOES THE WIND COME FROM?) WHEN THE MAN SWINGS THE WIND GOES "WOOO" LIKE THAT (DEMONSTRATES) ... (SO THE WIND IS PUSHING FROM THE BEGINNING) YES" 216

IS THERE A FORCE ON THE GOLF BALL (AS IT COMES DOWN)?
"I WOULD THINK (THE FORCE OF THE HIT) IS STILL ON IT AND THE FORCE OF THE AIR MAKING IT COME DOWN (THE AIR IS MAKING IT COME DOWN) YES ... THE ... I SUPPOSE GRAVITY (YES THING (IS THE FORCE OF THE AIR, THE SAME AS GRAVITY TO YOU OR ARE THEY DIFFERENT) SLIGHTLY DIFFERENT ... BUT MY WORDS TO EXPLAIN IT ARE LIMITED" 233

IS THERE A FORCE ON THE BEACH BALL ROLLING DOWN THE HILL?
"THERE MIGHT BE AT THE BACK OF IT PUSHING IT DOWN, TOWARDS THE GROUND (WHAT IS THIS FORCE?) UH ... OH WHAT'S IT CALLED I FORGET ... IT IS JUST THE ENERGY COMING DOWN PUSHING THE BALL DOWN TOWARDS THE GROUND BECAUSE THE ATMOSPHERE PUSHES THINGS DOWN (AIR PRESSURE?) YES THE FORCE OF THE AIR (IS THAT WHY ALL THINGS FALL DOWN, IF I LET THE PEN GO IT WILL FALL DON'T IT) YES (IS "NOT AIR PUSHING IT DOWN?) YES ITS THE AIR, THE ATMOSPHERE (IF WE DIDN'T HAVE ANY ATMOSPHERE?) IT JUST STAYS STILL" 217

"I WOULDN'T SAY THERE WOULD BE ... THE ONLY THING I CAN THINK OF IS THE AIR TYPE THING BEHIND IT MAKING IT SPEED UP BECAUSE OF THE TILT OF THE HILL" 233

IS THERE A FORCE ON THE MAN IN THE SATELLITE?
"THERE IS NO GRAVITY ..... HE IS OUT OF THE ATMOSPHERE" 213,227,232

IS THERE A FORCE ON THE MAN ON THE MOON?
"NO...I DON'T SEE ANY FORCE ON HIM...GRAVITY IS THE PULL OF THE AIR I THINK IF YOU TAKE AWAY THE AIR THERE WOULD BE NO GRAVITY AT ALL"236

EMPHASIS ON THE PERSON BY MAORI CHILDREN - A THEME

IS THERE A MAORI EMPHASIS ON THE PERSON WHICH IS GREATER THAN WE MIGHT EXPECT?
CONSIDER THE FOLLOWING:

11 YR OLD MAORI GIRL (208)
IS THERE A FORCE ON THE GOLF BALL?
"NO WELL UM ... WHEN YOU PLAY GOLF JUST ANYONE JUST HITS THE BALL ... THE PERSON WHO IS PLAYING GOLF ... THEY JUST HIT IT AND TRY TO GET IT TO THE HOLE ... AND PROBABLY IF IT DOESN'T LAND IN THE HOLE THEY JUST HIT IT AGAIN, AND IT PROBABLY GETS IN THE HOLE (SO THERE IS NO FORCE BECAUSE THIS IS JUST THE THINGS THEY DO?) YES (IS IT TO DO WITH PLAYING GOLF FOR FUN?) NO IT COULD BE CHAMPIONSHIPS (THERE STILL WOULDN'T BE A FORCE ON THE GOLF BALL?) NO. (SO BECAUSE THESE PEOPLE ARE PLAYING GOLF FOR FUN OR A CHAMPIONSHIP THERE IS NO FORCE ON THE GOLF BALL?) YES (COULD THERE BE A FORCE ON THE GOLF BALL DEPENDING ON WHO WAS PLAYING IT?) THERE COULD BE (WOULD IT DEPEND ON THE SORT OF PERSON WHO WAS HITTING IT?) YES ... (SO WHAT SORT OF ... LET ME TRY ... FOR EXAMPLE IF A SOLDIER CAME ALONG AND ANOTHER SOLDIER SAID YOU HIT THAT BALL OFF THE GOLF TEE ... IS THAT THE SORT OF THING YOU MEAN OR NOT ... WOULD THERE BE A FORCE ON THE GOLF BALL THEN?) THERE WOULD BE A FORCE ON IT ... IF THE PERSON WAS TOLD TO HIT IT ... (BUT IF HE JUST HIT IT BY HIMSELF AND IT WAS HIS OWN IDEA TO HIT IT ... THAT WOULD NOT BE A FORCE?) NO."

11YR OLD MAORI BOY (217)
IS THERE A FORCE ON THE DEMONSTRATOR
"IF HE HAS BEEN SMASHING WINDOWS AND VANDALISING THINGS THEY SHOULDN'T DO THAT ... THEY SHOULD GIVE HIM A WARNING OR SOMETHING INSTEAD OF FORCING HIM."

OTHER EXAMPLES SEE 217 ON "IS THERE A FORCE ON THE STATIONARY CAR?"

ANIMISM MAY BE A PROBLEM IN TEACHING? ... A THEME

A 9 YR OLD WHO SAID INANIMATE OBJECTS COULDN'T HAVE A FORCE ON THEM BECAUSE THEY COULDN'T FEEL ANYTHING.

IS THERE A FORCE ON THE GOLF BALL GOING UP?
"NO (BECAUSE THE GOLF BALL CAN'T FEEL ANYTHING) IT IS JUST MADE (LETS SAY WE COULD ROLL YOU UP INTO A LITTLE BALL THE SIZE OF A GOLF BALL SO YOU COULD FEEL SOMETHING) OH THAT WOULD HURT [THE HIT] (YES IT CERTAINLY WOULD ... O.K. NOW YOU ARE THE GOLF BALL AND YOU ARE UP HERE AND YOU CAN FEEL THINGS) YES (WHEN YOU ARE UP THERE WOULD THERE BE A FORCE ON YOU?) NO BECAUSE IT WOULD HAVE HURT DOWN THERE BUT UP HERE IT WOULD BE ALL RIGHT BUT WHEN YOU LANDED IT WOULD HURT TOO (SO IN THAT SENSE THERE IS A FORCE WHEN YOU HIT IT AND A FORCE WHEN YOU LAND?) YES" 204

BUT IT CAN THEN LEAD TO PROBLEMS E.G. GRAVITY MAY NOT BE A FORCE ALSO

IS THERE A FORCE ON THE BOWL?
"(I GUESS ACCORDING TO YOU THERE IS NOT A FORCE ON THE BOWL BECAUSE IT COULDN'T FEEL ANYTHING) NO (SO LETS IMAGINE YOU ARE THE BOWL WOULD THERE BE A FORCE ON YOU?) YES BECAUSE IF YOU ARE ROLLING AROUND YOU WOULD GET DIZZY AND SORT OF GET A BIT WOBBLING" 204